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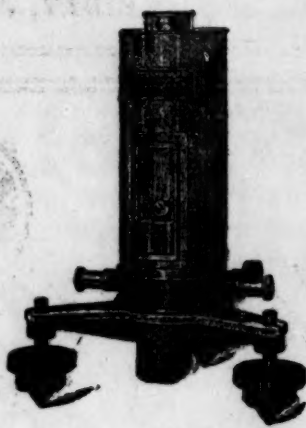
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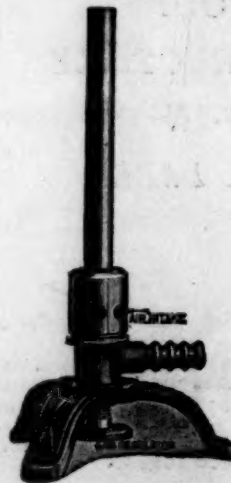
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TRANSMISSION OF ACTIVATION IN PASSIVE METALS AS A MODEL OF THE PROTOPLASMIC OR NERVOUS TYPE OF TRANSMISSION

ONE of the most remarkable peculiarities of irritable living cells and cellular elements like nerve fibers is the readiness with which chemical or metabolic influence may be transmitted, without accompanying transfer of material, between regions differing in the degree or character of their physiological activity. Thus one region of a muscle or nerve which is in a physiologically more active or "stimulated" state transmits its activity regularly to another more or less distant resting region. The state of activity aroused in the irritable living system by a localized stimulus does not itself remain localized, but tends to spread; the region immediately stimulated imparts a similar state of activity to adjoining regions, these then activate the next adjoining, and in this manner a wave of activation or excitation is propagated over the entire irritable element, often to a long distance from its point of origin. In many cases, as in nerve, there is no decrease in the intensity of the local process as it passes along the element; its characteristics are reduplicated both qualitatively and quantitatively at each point which it reaches in its course; the local excitation is temporary and quickly dies out, each successive region of the tissue becoming active and then returning automatically to its original state of rest. Transmission of this type is known to physiologists as "conduction," and is exhibited in its most highly developed form in the nerves of higher animals. It is, however, by no means peculiar to these structures; any cell or cell element which reacts as a whole to a local stimulus illustrates the same phenomenon; some disturbance affecting the metabolism and functional activity of the living system is radiated from the original

point of stimulation and activates the whole. The characteristic functional manifestation then appears—contraction in a muscle cell, motor reaction in a protozoon, cell division and development in a resting egg cell, etc. Conduction is in fact a widely general if not universal cell process. Excitation may thus be transmitted not only between different regions of the same cell or cellular element but also between different cells or elements which are in contact with one another; the transmission between neurones in the central nervous system and from a nerve to its muscle or other terminal organ illustrates this type of conduction. It is thus possible to distinguish between intracellular and intercellular conduction, although there is probably no essential difference between the two types.

Physiological transmission of the kind described seems to have in it something mysterious and specifically vital; in fact the problem of the essential physico-chemical nature of nerve conduction—the type phenomenon of this class—is still regarded by most physiologists as unsolved, and apparently by many as insoluble. The difficulty of the problem has been accentuated by the apparent lack of any close analogies with known inorganic processes. Comparisons with the electric current, with the transmission of mechanical influences such as elastic strain or vibration, and with the propagation of explosive waves or of germ-effects like crystallization in supersaturated solution, have all proved inadequate and often highly misleading. Yet it would seem that any phenomenon which is so universal in organisms and upon which many of their most characteristic activities directly depend—especially in animals—must have some general physico-chemical basis present also in inorganic nature. The problem is to find some simple and readily reproducible inorganic process, involving transmission of chemical influence, which is similar in its most general features to the conduction process in living cells, initiated under similar conditions, and dependent upon the same fundamental factors. What is to be looked for is not complete or detailed identity of the physiological process

with its inorganic model, but rather a class resemblance of a definite and unmistakable kind; the inorganic process should exhibit peculiarities which stamp it clearly as a phenomenon of the same essential kind as the physiological process. If the comparison is a true one, the transmission of chemical influence to a distance in cells or nerve fibers and the transmission of similar influence in the inorganic model should take place at similar rates, be influenced similarly by external conditions, be initiated by the same means, have the same external manifestations, and be dependent upon the same underlying physico-chemical factors. Just as the passage of the pulse wave in an artery and that of a distension wave in a simple elastic tube are both determined by general physical factors common to both objects, so the transmission of chemical or metabolic influence along a living conducting element like a nerve should—in the case of a valid comparison—depend upon certain fundamental features of physico-chemical constitution present also in the inorganic model. Is there in fact any known general class of non-vital physico-chemical phenomena to which we can thus assign the phenomenon of protoplasmic conduction?

In the stimulation of an irritable living structure by an external agent, the primary or releasing event is undoubtedly a surface process of some kind; the characteristic activation or “response” of the whole irritable element follows automatically upon this surface change. In most irritable cells any local mechanical or chemical alteration of the protoplasmic surface layer (or “plasma membrane”), or a slight change in its electrical polarization due to an electrical current, may cause excitation. There is little doubt, however, that the essential determining factors in any form of stimulation are *electrical*; and that mechanical and chemical stimuli excite the cell indirectly by means of the local electrical effects which they produce. The stimulating agent alters locally the structure or composition of the surface film; the state of electrical surface polarization is there changed; and the bioelectric circuit arising between altered and adjoining unaltered regions

completes the activation. This view at once explains why the electric current is the most universal stimulating agent. It is well known that stimulation of any cell, by whatever means induced, is always accompanied by an electrical variation of the cell surface, or current of action; and we find the same to be true of the propagation of the excitation wave. This last process, which is evidently essential to the stimulation of the cell as a whole, is apparently dependent upon the bioelectric circuit formed at the boundary between the active and inactive regions of the cell surface; that part of the local current which traverses the still inactive regions stimulates these electrically; the regions thus secondarily excited act similarly upon the resting regions next adjoining; the process repeats itself automatically at each new active-inactive boundary as it is formed, and in this manner the state of excitation spreads continually from active to resting regions. A wave of activation thus travels over the surface of the element.¹

If this theory of conduction is well founded, the chemical alteration of a surface film of material under the direct influence of local electrical circuits would seem to be indicated as the essential basis for the transmission. Changes of this kind are in fact a frequent phenomenon at the surfaces of metals in contact with solutions; and in a recent paper² I have called attention to the many striking analogies between the effects of such local electrolytic action in metals and the effects of local stimulation in living cells. For example, in the rusting of iron in aqueous solutions the formation of local electrical circuits between different regions of the metallic surface is now generally recognized to be the chief factor in the process. The surface layer of metal is typically not homogeneous, but exhibits local anodal and cathodal areas; at the former regions the ions of the metal enter solution and are precipitated as oxide or carbonate, while nascent hydrogen and alkali are presumably formed at the cathodal regions.

¹ Cf. *Amer. Jour. Physiol.*, 1915, Vol. 37, p. 348; 1916, Vol. 41, p. 126.

² *Loc. cit.*, 1916.

Each of the areas of local chemical action thus represents an electrode-area in a local electrical circuit; and electrolysis at these areas is what determines the chemical changes there taking place. Now electrolysis is a process in which the transmission of chemical influence to a distance without transfer of material is an essential and constant characteristic; the very flow of the current depends in fact upon this condition. Any electrochemical change at one electrode of a battery or other electrical circuit due to chemical action necessarily involves a corresponding change of a chemically opposite kind at the other electrode. Oxidation, the general effect at the anode, thus involves simultaneous reduction at the cathode; an oxidizing substance placed in contact with one electrode will thus instantly oxidize a reducing substance at the other electrode. Spatial separation of the two regions is a matter of indifference except in so far as it increases the electrical resistance of the circuit, thus retarding the rate of the electrochemical process. The transmission of the chemical influence between the electrodes is automatic and instantaneous.

This "chemical distance action"³ suggests a possible basis for the protoplasmic type of transmission, since distance action is a feature of all electrochemical circuits, including those present in local action at metallic surfaces. If therefore it could be shown that the cell surface can act like a metallic surface the essential difficulties of the problem of protoplasmic transmission might be regarded as overcome. An inconsistency, however, appears in the fact that the transmission of electrochemical influence in a circuit is instantaneous (*i. e.*, 3×10^{10} cm. per sec.), while the most rapid protoplasmic transmission—in the motor nerves of mammals—is only 120 meters per second; again, the intensity of chemical distance action decreases with the distance between the electrodes, because of the increase in electrical resistance, while in the nerve impulse there is normally no decrease in intensity (or "decrement") as the local change

³ Cf. Ostwald, *Zeitschr. physik. Chemie*, 1891, Vol. 9, p. 540.

passes along the fiber. Such difficulties are only apparent, however; in nerve conduction it is quite certain that an entirely new state of activity is aroused at each successive region of the fiber as the impulse passes; and all of the evidence indicates that the speed of transmission is determined mainly by the sensitivity and local rate of response of the nerve,⁴ and not at all by the rate of transmission of the electric current in the bioelectric circuit. It is probable that in the local bioelectric circuit set up by the initial stimulus the direct chemical influence of the current extends for only a short distance, at most a few centimeters from the original site of stimulation; but one of its effects is to originate a new and similar circuit in the adjoining regions of the fiber; this process repeats itself as already indicated, and in this manner the impulse spreads. The observed speed of the activation-wave has thus nothing to do with the speed of the purely electrochemical distance effect. What we seem to observe is a local electrical circuit which travels along the nerve together with the activation wave; but in reality there is a succession of new circuits, each of which automatically arises at the boundary between resting and active regions as the front of the activation wave advances. The relatively slow rate of movement of the impulse and the absence of a decrement may thus be understood.

The rapid passage of a wave of chemical decomposition (probably oxidative in nature and involving some structural change) over the surface of the reacting element, followed immediately by a reverse change which restores the original or resting condition, is what appears to take place in a nerve or other living structure during conduction. Associated with the chemical process is a local electrical circuit by whose electrolytic action the chemical change is apparently determined. Have we examples of similar processes in inorganic systems? It appears in fact that this general type of process is not unusual in metals in contact with solutions. Especially clear and

striking examples are seen in the transmission of the state of activity over the surface of metals, especially iron, which have been brought into the temporarily non-reactive or "passive" condition by immersion in strong nitric acid (or other suitable oxidizing agent) and are then placed in dilute acid and made to react. It has long been known that iron which has been thus "passivated" becomes resistant or refractory to reaction and (for example) no longer dissolves spontaneously when placed in dilute nitric acid (s. g. 1.20). But if while immersed in the dilute acid it is touched momentarily with a baser metal, or with a piece of ordinary non-passive iron, it is at once "activated" and reacts vigorously with the acid until dissolved.⁵ The experiment is a striking one and easily performed. In my own demonstrations a piece of pure iron wire (No. 20 piano wire, bent at one end into a hook for handling) is passivated by immersion in strong nitric acid (s. g. 1.42) for a few seconds, and is then placed (by means of a glass hook) in a flat dish containing dilute acid (s. g. 1.20). The wire if left undisturbed remains bright and unaltered for an indefinite time. If then it is touched at one end with a piece of ordinary iron, or with zinc or another baser metal, the bright metallic surface is at once darkened (through formation of oxide) and active effervescence begins; this change is transmitted rapidly, though not instantaneously, over the entire length of the wire; the velocity of transmission varies with the conditions, and is of the order of 100 or more centimeters per second in this experiment. The wave of activation may also be initiated *mechanically*, e. g., by bending the wire or tapping it sharply with a glass rod; or *chemically*, e. g., by contact with a reducing substance such as sugar; or *electrically*, e. g., by making the wire (while immersed in the acid) the cathode in any battery circuit (of two or more volts potential), preferably with another piece of passive iron wire as anode;

⁵ For a recent extended study of the passive state in metals with full references to the literature, cf. Bennett and Burnham, *Jour. Physical Chem.*, 1917, Vol. 21, p. 107.

⁴ Cf. *Amer. Jour. Physiol.*, 1914, Vol. 34, p. 414; Vol. 37, p. 348.

the cathodal wire is instantly activated, while the anodal wire remains unchanged. Activation with the electric current is thus typically a polar phenomenon, just as is the excitation of a living irritable element like a nerve.

Activation by contact with active iron or a baser metal is in reality an instance of electrical activation, the activating metal forming the anode of the local circuit arising at the region of contact. At the local cathode, *i. e.*, the adjoining passive iron, the metal is at once activated, and the effect spreads in the manner already indicated by means of the circuit which automatically arises at the boundary between active and passive areas. Any metal which thus activates by contact must be of such a nature that the passive iron becomes the *cathode* of the local circuit formed. A metal which is nobler than passive iron, like platinum, not only does not cause activation, but it renders the iron locally more resistant to activation; thus the passage of the activation wave may be blocked by the contact of a platinum wire. This latter effect depends upon the formation of a local circuit of the reverse orientation, the iron becoming anodal, a condition which furthers passivation and hinders activation. Active iron is a base metal in relation to passive iron, being more negative than the latter by *ca.* 0.75 volt in 1.20 HNO_3 ; hence when any region of a passive wire is rendered active it immediately activates the adjoining areas.

In passivation the surface layer of the iron is modified in a peculiar manner, apparently by the formation of a thin resistant layer of higher oxide. Any condition that interrupts locally this surface film of altered iron forms necessarily a local circuit by whose action the whole metal is activated in the manner just described. Apparently at any cathodal area the surface film of oxide is reduced to metallic iron; contact of a reducing substance has a similar effect; while a mechanical agent breaks the continuity of the film and exposes the unaltered iron beneath, thus forming the local circuit. The reason why mechanical, chemical and electrical influences all produce

the same effect is thus evident. The parallel to the living irritable tissue is plain; local alteration of the protoplasmic surface film produces effects of a closely comparable nature, which spread in an analogous manner by means of the local electrical circuits formed. We are thus enabled to understand why any rapid local alteration of the cell surface may activate the whole cell—in other words why the cell is so characteristically “irritable.” The iron wire in its passive state may be compared to the irritable living element in a state of rest. The state of inactivity continues in both cases only so long as the surface layer is intact and homogeneous. The reason why the *whole* cell (or the whole iron wire) responds completely to a local stimulus is simply because transmission over the entire surface follows automatically and inevitably upon local activation. The “all-or-none” behavior thus becomes intelligible.

Under normal conditions an irritable nerve or muscle returns spontaneously to an inactive or “resting” state after stimulation, and for renewal of activity a second stimulus is required. The resting condition thus represents a condition of equilibrium, which is temporarily disturbed by the stimulating agent. The same is true of the passive condition of iron in *strong* solutions of nitric acid. In weaker solutions, of *s. g.* 1.20 and less, the reaction once initiated continues unchecked until all of the iron is dissolved; but in stronger solutions *the reaction is temporary and the metal returns spontaneously to the passive condition.* A wave of temporary activity thus sweeps over the surface of a passive iron wire which is activated (*e. g.*, by touching with zinc) in nitric acid of *s. g.* 1.25 or higher; the state of local activity lasts in such a solution for a brief period only, which is the shorter the higher the concentration of the acid. An interesting gradation of effect may thus be shown by activating a series of passive wires in different dilutions of strong (*s. g.* 1.42) acid, *e. g.*, 90, 80, 70, 60 and 55 volumes per cent. (*i. e.*, 90 c.c. 1.42 HNO_3 plus 10 c.c. water, etc.). When a wire immersed in pure 1.42 acid is touched at one end

with a piece of zinc a momentary flash-like wave of activation is seen to pass rapidly along the whole wire; the local reaction lasts for only a small fraction of a second and is instantly reversed; a slight temporary darkening of the metallic surface and a trace of brown coloration (due to reduction of the acid to lower nitrogen oxides) are the only visible effects; in 90 per cent. acid a similar though somewhat more prolonged reaction takes place; in 80 per cent. acid there is slight visible effervescence for a fraction of a second; in 70 per cent. the effervescence lasts for about one second and the darkening of the metallic surface is more pronounced; while in 60 per cent. the reaction occupies two or three seconds and in 55 per cent. five seconds or more, and a considerable accumulation of brown oxide is formed at the surface of the metal. It would thus appear that in the stronger solutions the oxidation which forms the protective surface film takes place so rapidly that only a momentary reaction of the metal with the acid is possible; as the concentration of acid decreases the surface film forms more slowly and the reaction lasts longer, until at a certain critical concentration (about 50 per cent.; *ca.* 1.20 s. g.) the surface oxidation becomes so gradual that its passivating influence is insufficient to interfere with the continued solution of the metal in the acid.

Two chemical reactions of opposite character thus take place successively as the activation wave passes any region of the metallic surface; first, the local cathodic reduction which removes the protecting layer of oxide and enables the metal to react with the acid; and second, the immediately succeeding oxidative process which reforms the protective surface film and arrests the reaction. A factor of importance in this process of repassivation is apparently the electrochemical oxidative action at the local anode. As the activation wave advances, the surface film is disintegrated at the cathodal region immediately in advance of the wave front; this region then instantly becomes active, *i. e.*, anodal; in other words, it undergoes a change of condition which in itself tends to check or arrest the reaction.

This is because of the characteristic passivating influence at the anode; the reaction of a piece of active iron wire in 1.20 HNO_3 may in fact be brought to rest and the wire rendered passive by passing a strong current through it as anode for a few seconds.⁶ As the activation wave passes, each region of the metallic surface thus becomes alternately cathodal and anodal. Making the passive metal cathode has an activating effect, while making the active metal anode tends to passivate. This latter electrochemical action is added to the direct passivating action of the acid. Hence in acid of a sufficient strength the local reaction is automatically self-limiting as well as self-propagating. This peculiarity depends directly upon the properties of the surface film, which when the metal is cathode undergoes dissolution, and when the metal is anode is reformed. Apparently in strong acid the metal is in a condition where a slight local increase of reducing influence initiates the activating reaction and a slight increase of oxidizing influence inhibits it. We have here another parallel to the condition in an irritable element like a nerve fiber, where cathodal polarization promotes and anodal polarization inhibits the local reaction (electrotonus). In both cases the alternate disintegration and reformation of a surface film under electrochemical influence appear to be the essential features of the local process.

The passage of the wave of activation can be observed with especial clearness in a passive iron wire which has been dipped in a test-tube containing 1.42 HNO_3 and is then suspended vertically in air and touched at its lower end with zinc. The adhering layer of acid is so thin as to increase greatly the resistance of the local circuit between active and inactive regions, and the local reaction spreads with corresponding slowness, at a rate of only a few (5 to 10) centimeters a second. As the

⁶ Contact of a piece of platinum foil with a reacting iron wire has the same effect; near the platinum the iron soon ceases reaction and becomes passive, and the effect then spreads over the whole wire. This phenomena is biologically interesting, as a case of transmission of inhibitory influence.

reacting region extends upward the bright surface of the iron is darkened locally for a distance of two or three centimeters; behind this advancing active region the wire again becomes bright and inactive. The visible effect is that of a slight temporary darkening or clouding which travels upward along the wire. After the wave has passed over the whole length of the wire the latter, when tested by dipping in 1.20 acid, is found to be again passive; the temporary and reversible character of the activation is thus shown. A similar slow spreading of the active state takes place in a passive wire dipped in weaker (1.20) acid and then activated as above, but in this case there is no spontaneous return to passivity; the whole wire remains dark, and when again placed in 1.20 acid at once reacts vigorously in the usual manner of active iron. Spontaneous reversal thus takes place only in the strong acid.

In the experiment just cited the rate of transmission is lowered by increasing the electrical resistance of the local circuit, but in other respects there is no essential difference from the conditions observed in immersed wires. A noteworthy feature of these phenomena is that after a wire has been activated while immersed in strong acid (*e. g.*, 80 per cent. 1.42) some time elapses before a complete reaction can be again excited; *i. e.*, a period of insensitivity and imperfect transmission always follows the spontaneous return of passivity. Contact with zinc within the first four or five minutes after activation causes typically only a local reaction which may be transmitted slowly for a few centimeters but then dies out; some minutes later transmission takes place more rapidly and through a longer distance; but it is usually only after ten or fifteen minutes (the exact time varying with the conditions) that perfect transmission through an indefinite distance becomes again possible. The recovery of the original condition thus requires some time, the exact interval varying with the concentration of acid, and in general decreasing with decreasing concentration. This phenomenon also has its biological analogies, and may be compared to

fatigue, or possibly to the refractory period which typically follows stimulation in all irritable tissues. Evidently the reformed surface film regains its former sensitive properties by a progressive and somewhat gradual process.

This tendency to an automatic restoration of the protective surface layer of oxide after local removal is probably the essential condition underlying another characteristic feature of the electrical activation of passive iron, namely, that a slowly increasing current passed through the wire (as cathode) is much less effective in causing activation than a current of similar strength which attains its full intensity rapidly or instantaneously. In this respect also the passive metal resembles the living irritable tissue. If the current leading to the two passive wires immersed in 1.20 HNO_3 is derived by means of a stationary and a movable zinc electrode from a bath of zinc sulphate solution forming part of a circuit of several storage cells—an arrangement enabling the potential of the "shunt current" to the iron wires to be varied at will—it is found that a gradual increase of the current, from near zero to an intensity which in itself is amply sufficient to activate with sudden closure, is typically without effect. Evidently a *sudden* change of surface polarization is needed; if the change is gradual it seems that the oxidative action of the acid in contact with the metal has time to reform the passivating protective layer as fast as it is reduced by the cathodal action.

The chief of the foregoing resemblances between the passive iron wire and the irritable living element may now be briefly summarized as follows: (1) Mechanical, electrical and chemical agencies have the same activating effect; (2) electrical activation is a polar phenomenon (analogy to the law of polar stimulation); (3) the local state of activity is propagated along the wire at a velocity which is similar in its order to that of the excitation wave in living tissues; (4) whenever activation is excited by any means in a passive wire immersed in a definite solution of acid (*e. g.*, 70 per cent. 1.42 HNO_3) the *whole* wire is

involved and the reaction lasts for a definite time; *i. e.*, the character, intensity and duration of the reaction are independent of the nature of the activating agent; the metal either reacts completely or not at all (analogy to the "all-or-nothing" behavior of irritable living elements); (5) a wire which is polarized anodically while immersed in acid is activated with difficulty and the activation wave tends to travel for only a short distance (analogy to anelectrotonus in nerve); (6) the spontaneous return of passivity in strong acid is immediately succeeded by a period during which the metal is less responsive than before (analogy to fatigue effect or refractory period); (7) a current which reaches its full intensity gradually is less effective than one which reaches the same intensity suddenly; and finally (8) the local chemical surface reaction of activation is constantly associated with a variation of electrical potential, the active region becoming negative relatively to the inactive regions (analogy to the bioelectric variation or "action current" of an active living tissue).

The chief characteristics of this electrical variation are readily demonstrated as follows. When two iron wires connected with the binding-posts of a voltmeter of suitable scale are passivated and placed side by side in a vessel containing 1.20 HNO_3 , no potential difference is shown. If then one wire is activated the instrument at once indicates a P.D. of 0.7 to 0.8 volt, with the active wire negative; this P.D. remains constant while the reaction continues in the one wire; if then the other wire is also activated the P.D. again falls to zero. The active wire is thus anodal, the passive wire acting like a noble metal. If the same experiment is performed with stronger acid (55 per cent. 1.42 or higher) a similar but *temporary* excursion of the needle is seen, lasting for the period of the reaction. In acid of 55 or 60 per cent. the potential exhibits irregular rhythmical fluctuations for the few seconds during which the reaction continues, and the needle swings by degrees back to zero and somewhat beyond as the reaction subsides and ceases. Immediately after the

return of the passive condition the activated wire is always found slightly more positive than before, usually by *ca.* 0.02 volt; after an interval of some minutes—corresponding apparently in its duration to the insensitive or refractory period above described—the original potential returns. The wire may then be again reactivated and the same process is repeated. This tendency to overpass the original potential after the return of passivity recalls the similar phenomenon in nerve known as the "positive after-variation," and suggests a similarity in the general conditions under which the surface film is reconstituted in the two cases.

The variation of potential associated with the transmission of the activation wave may be demonstrated in a single wire which is connected near its opposite ends with a sensitive string galvanometer (by means of thin passive iron wires) and immersed in 70 or 80 per cent. acid. If the wire is activated at one end the string shows a quick excursion, first in the one direction, then in the other, the deflection showing that at each leading-off region the wire becomes first negative and then positive. The curve of movement is thus comparable to the typical "diphasic" action current curve of a nerve conducting an impulse.

The amplitude of these variations of potential in metals is of course much greater than that found in living tissues, but in their general characteristics both classes of phenomena give unmistakable evidence of being conditioned in the same manner. In the case of the metal it is certain that the effect depends upon a sudden alteration of the electromotor properties of the surface layer. In living tissues and cells there is also much evidence that a change in the protoplasmic surface layer (or so-called plasma-membrane) involving increased permeability and altered metabolism is constantly associated with stimulation, and that the variation of electrical potential is due primarily to this change. Thus in both living system and metal the electrical variations are the expression or indication of changing chemical and structural conditions in the surface layer. The local interruption

or removal of the surface film of oxide in the metal is comparable with the increase of permeability in the living element.

A significant general analogy to physiological conditions is also to be seen in the readiness with which the active state is transmitted from an active to a passive metal by contact. Transmission of excitation from one cell or cell element to another by contact is frequent in organisms; and many characteristic structural arrangements, especially in the nervous system, give evidence that such transmission is a normal and constant physiological process; the interlacing of dendrites from different neurones, contact of nerve cells with one another by "end-feet" and similar structures, the histological characters of the myoneural junctions and other nerve endings—which typically form contact with the surface of the cell—may serve as examples. Instances of transmission by contact in metals have been given above. A good demonstration is the following: if a number of passive iron wires are placed in contact with one another in a dish of nitric acid, and any single wire is touched with zinc, *all* immediately become active. A long fine passive wire in contact at one end with a large piece of passive iron, *e. g.*, a nail, will on activation at its other end rapidly conduct and transmit the state of activation to the terminal object. Another remarkable feature of this phenomenon is that the transmission between different metals may be *irreciprocal*; this may be shown by using wires of the two metals, iron and nickel, which differ in the readiness and rate with which activation takes place. A momentary contact with active nickel will instantly activate a piece of iron wire in 1.20 HNO_3 , but under the same conditions a piece of passive nickel is activated slowly and only after prolonged contact. Consequently, while briefly touching passive iron with active nickel immediately and completely activates the iron, touching passive nickel with active iron is typically ineffective or has only slight local effect. In other words, transmission of activation takes place rapidly and readily from nickel to iron, but not in the reverse direction. The differ-

ence depends upon the relative slowness of the activation process in nickel; in this metal the local reaction tends to start slowly and to reach its maximum slowly, and the rate of transmission is correspondingly gradual. Such facts suggest the possibility that the characteristic irreciprocity of transmission in reflex arcs may depend upon similar differences in the time factors of excitation of the interacting neurones at the synapses. The recent work of Lapicque and Keith Lucas has shown clearly the fundamental importance of the time factor in the excitation process.⁷

It seems clear that variations in the electro-motor properties of the surfaces concerned—respectively the metallic surface and the cell surface—form the essential feature of activity which is common to both types of system and upon which the above various similarities of behavior depend. These variations are due to changes in the physical and chemical character of the surface layer, which in both cases is water-insoluble, chemically unstable, and in contact with an electrolyte solution. Experiment shows that in the passive metal this surface film is in a characteristic state of equilibrium which is readily disturbed, and the same appears to be true of the protoplasmic surface film in an irritable cell or cell element.

This general similarity probably explains another peculiarity of behavior common to both systems, namely a tendency to automatic rhythmical fluctuations of potential and chemical action; this phenomenon is seen in the solution of many metals in nitric acid, and also in the well-known rhythmical catalytic decomposition of hydrogen peroxide in contact with mercury. Alternation of activity and passivity, due to rhythmical formation and dissolution of a surface film of oxide or other protective material, appears to underlie these phenomena in metals. In living organisms rhythmical action is also highly characteristic, and is presumably due to analogous conditions.

The general view that the semi-permeable

⁷ Similarly with transmission from element to element. Lapicque's work indicates that the failure of transmission from nerve to muscle in curare poisoning is due to "heterochronism."

cell surfaces may have electromotor properties similar in certain respects to those of metallic surfaces has long been familiar to physiologists; and the so-called "membrane theory" (or theories) of the bioelectric potentials, which originated in a suggestion of Ostwald in 1890 and has been developed in considerable detail by Bernstein, Höber and others, has referred the physiological variations of potential to variations of permeability or to other changes in the plasma-membrane. It seems best, however, to avoid for the present too special conceptions of the precise nature of the processes concerned in these phenomena and to regard the latter from a broader and more generalized point of view. Variations of phase-boundary potentials, with associated or dependent chemical effects, appear to constitute the general type of phenomenon involved. More recently the work of Haber, Beutner and especially of Loeb and Beutner in collaboration, has demonstrated many fundamental resemblances between such potentials and the bioelectric potentials, and is of the highest interest in relation to this general problem. The work of Loeb and Beutner, together with that of Macdonald, indicates that organic membranes and cell-surfaces behave as if reversible (in the electrochemical sense) to cations as a class; in this respect they resemble the surfaces of solutions of lipoids in organic solvents; and it seems probable that the demarcation-current potentials are thus to be explained. I am inclined, however, in view of the conditions in passive iron as well as for more purely biological reasons, to regard the local bioelectric circuits accompanying normal cell activity as representing primarily some type of oxidation reduction element. In general the physiological effects observed at the respective regions where the electric current enters and leaves the cell-surface are *opposite* in character, and the same must be true of the underlying chemical or metabolic processes. Oxidation at one area, simultaneously with reduction at another area—these chemical changes involving synthesis as well as decomposition—seems to be a more probable source of the normal currents of

action, especially when the dependence of vital phenomena on oxidation and synthesis and the interdependence of the two latter processes are considered. Further discussion of the possible relations between the bioelectric processes and cell-metabolism, with a fuller account of the facts described in this article, must be reserved for a more complete paper.

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THE INTER-ALLIED SCIENTIFIC FOOD COMMISSION¹

THE Inter-Allied Scientific Food Commission now sitting in London has already at previous meetings accomplished a good deal of work, and if its recommendations are carried out, the provisioning of allied countries will be placed on a sound scientific basis. That its recommendations will be carried out seems to be more or less guaranteed by the fact that it was established as a result of a decision of the Inter-Allied Conference held in Paris last November. The Conference directed that the inter-allied scientific commission should consist of representatives of France (Professors Gley and Langlois), Italy (Professors Botazzi and Pagliani), United States (Professors Chittenden and Lusk), and the United Kingdom (Professors E. H. Starling and T. B. Wood). It was instructed to meet periodically in order to consider from a scientific point of view the food problems of the Allies and in agreement with the inter-allied executives to make proposals to the allied Governments. The commission held its first meeting in Paris on March 25, and its second in Rome on April 29. Before its present meeting in London a representative of Belgium, Professor Hulot, was added. A memorandum upon the work of the commission, furnished to us by the food controller, contains some particulars enlarging the information published in previous issues.

At its first meeting last March in Paris the commission came to an agreement as to the minimum food requirements of the average man. It was laid down that for a man weigh-

¹ From the *British Medical Journal*.

ing 70 kilos, or 154 lb., doing average work during eight hours a day the food as purchased should have an energy value of 3,300 calories a day, but that a reduction of 10 per cent. could be supported for some time without injury to health. The commission accepted the figures of Professor Lusk, one of the representatives of the United States, for the proportion to be assigned to women and to children of different ages. At the second meeting, in Rome, the metric ton (a metric ton is 0.9842 ton British) was adopted as the unit for estimating the weights of the various foods produced in each allied country. A "man value"—that is to say, the number of average men equivalent to the population of each of the allied countries—was established, and was taken as a basis for calculating the amount of food to be provided for the adequate nourishment of the total population of each country. An estimate was then formed of the home production of the soil furnished by each allied country in 1918-19 to serve as a basis for determining the amount of food available for men and animals, respectively, in each country.

It was not thought desirable to fix a minimum meat ration, in view of the fact that no absolute physiological need exists for meat, since the proteins of meat can be replaced by other proteins of animal origin, such as those contained in milk, cheese and eggs, as well as by proteins of vegetable origin. It was, however, considered desirable to fix a minimum ration of fat; this it was decided should be 75 grams—about 2½ oz. per average man a day. It is to be noted that the fat ration may be made up from fats partly of vegetable origin and partly of animal origin, and the commission expresses the opinion that if the amount of fat of vegetable origin was found to be insufficient it might be necessary to maintain a certain stock of animals to make good the deficit.

The commission has recommended that the maximum possible proportion of all cereals except oats should be reckoned in when calculating the amount of calories available for man. As to milling, it has advised that a

uniform extraction of 85 per cent. should be adopted in all the allied countries; this will vary from 80 per cent. in summer to 90 per cent. in winter, and will apply to the United States only as regards their internal consumption, and then only in case of scarcity. While man should always take precedence over animals in the allocation of food by governments, it is recognized that the methods adopted for reserving the maximum possible proportion of the cereals for the use of man may vary in each country. The opinion is therefore expressed that in fixing prices it is the prices of animal products which should be limited rather than those of such vegetable products as may serve equally well for feeding men and animals. The production of veal, pork and poultry at the expense of other food immediately available for man should therefore be discouraged and this may best be done by fixing prices for those animal products which will make it unprofitable for the producer to feed the animals on cereals. The chief subject now under consideration is the examination of statistics which will render it possible to ascertain the calorie value of the home production of each of the allied countries. The comparison of these figures with the needs in calories of the population of each country will enable the commission to deduce the amount of imports necessary for the maintenance of the population, or the exportable surplus, as the case may be.

The commission has also expressed the opinion that any propaganda having for its object the encouragement of food production and of economy in the use of food should be organized and directed by men of science well acquainted with the subject. The members of the commission itself fulfil this condition, to the importance of which we had occasion some time ago to call attention, for this elementary principle was at first neglected in this country. It appears that the truth of this principle is beginning to be recognized in Germany, where voices are being raised in favor of consultation of scientific and medical experts by the authorities.

SCIENTIFIC EVENTS

THE ASPHALT INDUSTRY IN 1917

THE war has stimulated activity in the domestic markets for asphaltic material derived from crude petroleum and for imported asphalt, but the relative abundance and adaptability of those materials has lessened the demand for the native bitumens and for the various types of bituminous rock produced in this country, according to statistics just completed under the supervision of J. D. Northrop, of the United States Geological Survey, Department of the Interior.

The native bitumen, including maltha, gilsonite, elaterite and grahamite, bituminous rock and ozokerite, marketed from mines and quarries in the United States in 1917 was 80,904 short tons, a loss of 17,573 tons, or 18 per cent., compared with 1916. The market value of the output in 1917 was \$735,924, a loss of \$187,357, or 20 per cent., compared with 1916.

The production of gilsonite, bituminous sandstone, bituminous (elaterite) shale, and ozokerite was increased considerably in 1917, but the gain credited to these varieties was insufficient to offset the loss in the production of elaterite, grahamite and bituminous limestone.

The quantity of manufactured asphalt (including road oils and flux) produced in 1917 from petroleum of domestic origin increased about 2 per cent. compared with 1916, and the quantity of corresponding material manufactured in this country from Mexican petroleum increased about 13 per cent., as a consequence of which the net gain over the production in 1916 was nearly 7 per cent.

The total sales in 1917 of manufactured asphalt derived from domestic petroleum amounted to 701,809 short tons, valued at \$7,734,691. This total includes 327,142 tons, valued at \$4,011,980, of solid and semisolid products used in the paving and roofing industries, and 374,667 tons, valued at \$3,722,711, of liquid products, including road oils, flux and asphaltic paints.

California maintained its supremacy in the production of oil asphalt. Its output from 14 petroleum refineries in 1917 aggregated 220,

294 tons, valued at \$2,100,252, and included 135,160 tons of solid and semisolid products, valued at \$1,486,609, and 85,134 tons of liquid products, valued at \$613,643. Refiners handling oil from the Oklahoma-Kansas field produced 206,223 tons of oil asphalt, valued at \$1,957,493, including 73,410 tons of solid and semisolid products, valued at \$747,651, and 132,813 tons of liquid products, valued at \$1,227,842.

The total sales in 1917 of manufactured asphalt derived from Mexican petroleum amounted to 645,613 short tons, valued at \$7,441,813, and included 338,485 tons of solid and semisolid products, valued at \$4,657,152, and 307,128 tons of liquid products, valued at \$2,784,661.

The imports of native asphalt, oil asphalt, and bituminous rock for consumption in the United States in 1916 aggregated 187,886 short tons, valued at \$993,115, a gain in quantity of 40,173 tons, or 28 per cent., over 1916. The exports of unmanufactured asphalt in 1917 amounted to 30,107 short tons, valued at \$587,256, a loss of 10,709 tons, or 35 per cent., compared with 1916. In addition asphalt products to the value of \$585,472, compared with \$494,895 in 1916, were exported in 1917.

TRAINING CAMPS FOR INSTRUCTORS TO PREPARE COLLEGE MEN FOR MILITARY SERVICE

THE War Department authorizes the following statement from the Adjutant General's office.

Training camps to fit men to act as assistant instructors in the new Students' Training Corps will be held at Plattsburg, N. Y., Fort Sheridan and Presidio, Calif., from July 18 to September 16. Colleges have been invited to send a limited number of picked students and members of the faculties to these camps.

The camps will be conducted with a view to teaching the attendants to give military instruction to students, and it is believed that satisfactory results can be obtained from an intensive 60-day course.

Further instructions relative to the new corps have just been issued. These are being sent to all colleges that have signified their

willingness to establish corps among their students.

The purpose of the new plan, as shown in the new instructions, is to develop as a great military asset the large body of young men in the colleges. This will be accomplished by providing efficient military instruction under the supervision of the War Department for students in all colleges enrolling the required minimum of students. In order to receive this instruction, all students over eighteen years of age must volunteer and enlist in the army of the United States.

Only colleges which can provide an enrollment of 100 or more able-bodied students over eighteen years will be entitled to the course. The intention is to extend the system of instruction for college students to the largest practicable extent in view of the available supply of officers and equipment. To be classified as one of the institutions of college grade to which the privilege of maintaining a Students' Army Training Corps unit is extended, an institution must require for admission to its regular curricula graduation from a standard secondary school or an equivalent; must provide general collegiate or professional curricula covering at least two years of not less than 33 weeks each; and must be carried in the lists of higher institutions prepared by the United States Commissioner of Education.

Institutions of college grade will include, providing all other conditions are met: Colleges of arts and sciences; engineering schools; schools of mines; agricultural colleges; colleges of pharmacy, veterinary, medicine; teachers' colleges, and law, medical, dental, graduate and normal schools; junior colleges and technical institutions. Students enrolled in preparatory departments of these schools and colleges can not at present be considered eligible for enlistment in the units, and such students can not be counted by college authorities in reckoning the 100 able-bodied students for a military training unit.

The character of the training will depend on the kind of training unit which is organized in the particular institution. The standard time to be allotted to military work will be 10 hours

per week during the college year supplemented by six weeks of intensive training in a summer camp. The 10 hours a week will not involve the hours of outdoor work in drill.

The summer camps will be an important feature of the system. These will be active for six weeks, and there will be an intensive and rigid course of instruction under experienced officers.

The plan will provide approximately 650 hours of military work per annum. It is expected that this will qualify a considerable percentage of the students to enter officers' training camps on being called to the colors, and a large percentage of the remainder to serve as noncommissioned officers.

Officer instructors and noncommissioned officer instructors will be provided by the War Department when available. Officers returning from overseas and unfit for further field service will be utilized. The government will supply the uniforms and equipment whenever available.

The Students' Army Training Corps will be supervised and controlled by the training and instruction branch, war plans division of the General Staff, in accordance with the instructions of the Chief of Staff. An advisory board to this committee, representing educational interests, has already been appointed by the Secretary of War. This will insure the closest cooperation between the War Department and the colleges.

GUARDING SOLDIERS' CAMPS AGAINST FLIES AND MOSQUITOES

THE following statement is authorized by the War Department from the Surgeon General's office:

To guard troops stationed in camps and cantonments from disease carried by mosquitoes and flies, the medical department of the Army has installed a system of prevention which is safeguarding not only the soldiers but also civilians living in the neighborhood of training camps.

There is attached to each camp a division surgeon who is responsible for the health of the camp. Assisting him is a sanitary inspector who has the assistance of a sanitary

engineer and from 100 to 200 enlisted men who are continually employed in work designed to protect the health of the soldiers.

Special attention is now being given in all camps to cleaning up spots where mosquitoes and flies breed. In some cases it has been necessary to dig channels in streams, drain swamps, and put in elaborate ditching systems in order to clean up stagnant pools and streams. In those cases where it has been found impossible or impracticable to drain swamps and to do other work of a similar nature, there has been installed a system for keeping these slow-moving streams and still bodies of water covered with oil. At all points within the camp where there is the slightest possibility of mosquitoes or flies breeding daily spraying of oil is done.

Arrangements have been completed with the Federal Public Health Service to carry out a similar program in the territories adjacent to the camps. The Health Service has agreed to fill bogs, open streams and drain swamps and continue the oil spraying for a distance of 1 mile around all camps.

Special precautions have been taken to prevent the spread of disease by flies. With the approach of the fly season a general order was sent to all division surgeons and other health officers to take all necessary steps to prevent the breeding of flies. Instructions were given on the disposal of materials that were likely to become breeding spots. Arrangements were made to protect all food from flies. With this end in view all buildings in which food is prepared or stored were screened. The entrance to the buildings have been vestibuled. An added guard is the placing of flytraps in all buildings. An average of 6,000 such traps have been placed in each camp. More than 22,700,000 square feet of screening has been placed in all camps.

THE WEATHER BUREAU AND DR. CLEVELAND ABBE

THE Secretary of Agriculture has removed Dr. Cleveland Abbe, Jr., from his position in the Weather Bureau by the following order:

For the good of the service you are hereby removed from your position as meteorologist in the

Weather Bureau of this department, effective at the termination of July 3, 1918.

In transmitting Mr. Houston's order Dr. C. F. Marvin, chief of the Weather Bureau wrote:

I find myself confronted with the most painful duty of transmitting to you the inclosed letter, received this morning from the department, removing you from the government service. The reasons for this action are connected altogether with your conduct and your long-standing and generally well-known friendly sympathies for the imperial German government.

The bureau is not in possession of any of the details of investigation or records leading to this action by the secretary, but it is known to result from investigations made by the Department of Justice, and which I may say were not the result of any suggestions or representations by employees of the Weather Bureau, but were initiated entirely by outside sources.

A searching inquiry of your innermost heart in respect to your attitude toward the United States government must convince you that patriotism and genuine loyalty to the United States are absolutely incompatible with friendly sentiment for Germanism.

Denial of these charges is made in a letter written to Dr. Marvin by Dr. Abbe on July 7. The letter follows:

Your communication of the third, transmitting the very brief but astounding and inexplicable letter of the Secretary of Agriculture, so overwhelmed me with new duties and emotions that I have but now come to the realization of the unjust and even insulting accusations it contains to the effect that I have "friendly sympathies for the imperial German government" and "friendly sentiments for Germanism." These I must indignantly deny.

We have spoken together on this subject and you know that I have always distinguished between the German people and the actions of the imperial government since 1914, and I am glad to see that your letter indicates that you do not believe the truth of the statements you make concerning me. If you did believe them, duty would have required you to report me to the Department of Justice; but you state explicitly that the present action is "not the result of any suggestions or representations by the employees of the Weather Bureau." However, since you have placed such a statement

concerning me in the Weather Bureau files on this matter, I must ask to register herewith, in the same files, my indignant denial of any friendly feeling toward or sympathy for the imperial German government and my abhorrence of its official acts. I also repudiate indignantly the suggestion that I have, or could have, anything in common with what is now currently known as "Germanism."

It should not be necessary, but I once again do protest my sincere, genuine and undivided loyalty to the United States and to its government, its ideals, and particularly its published objects in this war. The most searching inquiry of my own acts and feelings fails to reveal to me any deficiency in this respect. It is well known to you that I have subscribed to the extent of my ability to the second and third liberty loans, to the Red Cross and its work, and to other activities.

You are, yourself, convinced of the truth of my statements, and, as you do not wish to see an unjust disgrace laid upon the name I bear, I believe you will aid my efforts to secure the common justice of an opportunity to learn from the Secretary of Agriculture the charges collected against me and to answer them fully in his presence.

GROVE KARL GILBERT

In the *Journal of Geology* Professor Thomas C. Chamberlin pays the following editorial tribute to the late Dr. Gilbert:

The passing of Dr. Gilbert after almost seventy-five years of activity deprives geological science of one of its ablest and most honored representatives. It is permitted to few men to leave an equally enviable record. To an unusual degree his work was distinguished by keenness of observation, by depth of penetration, by soundness in induction, and by clarity of exposition. It is doubtful whether the products of any other geologist of our day will escape revision at the hands of future research to a degree equal to the writings of Grove Karl Gilbert. And yet this is not assignable to limitation of field, or to simplicity of phenomena, or to restriction in treatment. The range of his inquiries was wide, his special subjects often embraced intricate phenomena, while his method was acutely analytical and his treatment tended always to bring into declared form the basal principles that underlay the phenomena in hand.

In the literature of our science the laccolith will doubtless always be associated with the name of Gilbert. In its distinctness as a type, in its uniqueness of character, and in the definite place it was

given at once by common consent, one may almost fancy a figurative resemblance between the laccolith and its discoverer and expositor. Gilbert's monographs on the Henry Mountains and on Lake Bonneville will long stand as unexcelled models of monographic treatment. His contributions to physiographic evolution, particularly his analysis of the processes that end in base-leveling, link his name with that of Powell, and give to these two close friends a unique place as joint leaders in interpreting morphologic processes. Glacial and hydraulic phenomena were also fields in which Gilbert's powers as an investigator and expositor were signally displayed.

In accuracy of delineation, in clearness of statement, and in grace of diction Gilbert's contributions are certain long to stand as models of the first order. His personality was of the noblest type; he was a charming companion in the field; he was a trusted counselor in the study. The high place he has held in the esteem of coworkers is quite certain to merge into an even higher permanent place to be accorded him by the mature judgment of the future.

SCIENTIFIC NOTES AND NEWS

THE annual convocation meeting of the American Federation of Biological Societies will be held this year in Baltimore. The date of the meeting is from December 30 to January 1 inclusive. The federation includes the following national societies: The American Physiological Society, the American Society of Biological Chemists, The American Society for Pharmacology and Experimental Therapeutics, and the American Society for Experimental Pathology.

DR. J. M. T. FINNEY and Dr. William S. Thayer, chief consultants of the Medical Service of the American Expeditionary Forces, have received promotions advancing their rank from major to colonel. The following named officers have been promoted from major to lieutenant-colonel: Thomas R. Boggs, James T. Case, George W. Crile, Harvey Cushing, Joel W. Goldthwait, James F. McKernon, Charles H. Peck, Thomas A. Salmon, Hugh H. Young, N. Allison and E. L. Keyes.

CAPTAIN JOSEPH LEIDY, who has been instructor in gas defense and divisional gas officer of the 30th Division, Camp Sevier,

S. C., has been assigned to the Brady Laboratory, Yale University Medical School, New Haven, Conn., in connection with the Gas Defense Service of the Medical Officers' Training School.

DR. TREAT B. JOHNSON, professor of organic chemistry in the Sheffield Scientific School of Yale University, is cooperating in research with the chemical section of the War Department, and is acting as director of a field laboratory which has been established in Yale University for gas experimentation work. Associated with him in this work are: Dr. Arthur J. Hill, Dr. Blair Saxton and Dr. Sidney E. Hadley, of the Department of Chemistry, Yale University. Dr. Norman A. Shepard, of the department of chemistry, at Yale University, is working in conjunction with Professor Johnson during the summer months, and is carrying on experimental work dealing with the manufacture of explosives for the government.

At the request of the President, the Secretary of Agriculture has designated as members of the National Research Council Henry S. Graves, forester and chief of Forest Service; Karl F. Kellerman, associate chief, Bureau of Plant Industry, and Raphael Zon, chief Forest Investigations.

DR. RAYMOND F. BACON, of the Mellon Institute of Pittsburgh, now lieutenant-colonel, chief of the Technical Division on General Pershing's staff in France, while on a short visit to this country, was given an honorary doctor of science degree by the University of Pittsburgh.

At the recent commencement of Yale University, Professor Emeritus Theodore S. Woolsey, of the Law School, in introducing Professor E. S. Morse for the honorary degree spoke as follows:

Edward Sylvester Morse—Born in Portland eighty years ago, a student with Agassiz, in the chair of zoology at Bowdoin, the pursuit of Brachiopods led Professor Morse to Japan. Three years in the Orient changed the current of his life. As collector, man of taste and man of letters, he has interpreted Japanese ceramics and Japanese char-

acter with loving fidelity. As head of the Peabody Museum in Salem since 1881, he has built up a wonderful institution. As zoologist and ethnologist he has won an enviable name. A double life is his, the happy union of science and of art.

THE Angrand Foundation of France has awarded a prize of five thousand francs to Dr. Herbert J. Spinden, assistant curator in anthropology at the American Museum, in recognition of his memoir on *Maya Art*, published by the Peabody Museum of Harvard University. This prize is awarded once in five years for original investigations in the anthropology of North and South America. Dr. Spinden is engaged at present on reconnaissance work in South America.

DR. HENRY FAIRFIELD OSBORN, president of the American Museum of Natural History, has been elected an honorary member of the Royal Irish Academy.

DR. E. R. WEIDLEIN, of the Mellon Institute, has been appointed by President Nichols to represent the American Chemical Society on the Committee on the Supervision of Chemical Engineering Catalogue and as a member of the Perkin Medal Committee and the Committee on Cooperation between Industries and Universities in place of Colonel R. F. Bacon, who is now in foreign military service.

CHARLES T. KIRK has resigned the positions of professor of geology in the university and the state geologist of New Mexico, to begin consulting practise in geology with offices in Tulsa and Oklahoma City, Oklahoma.

At a recent meeting of the Columbus Section of the American Chemical Society, Dr. W. D. Bancroft made addresses on "Gas warfare," and on "Contact catalysis."

A PORTRAIT bust of the late F. Massei, professor of otorhinolaryngology at the University of Naples, was recently installed in the hospital where most of his work has been done.

THE REV. GEORGE M. SEARLE, superior general of the Paulist Fathers from 1904 to 1909, and previously professor of mathematics and director of the astronomical observatory of

the Catholic University, died on July 8, at the age of seventy-nine years. Dr. Searle graduated from Harvard College in 1857 and held positions in the Dudley, Naval and Harvard observatories.

PROFESSOR STEPHEN FARNHAM PECKHAM, known for his work on the chemistry of bitumens, died on July 11, in his eightieth year. Professor Peckham was a graduate of Brown University in the class of 1861, and was professor of chemistry in the University of Minnesota from 1873 to 1880. Subsequently, he was engaged in the work of the U. S. Census, and was in the department of finance of New York City until his retirement in 1911.

LIEUTENANT VERNON KING, formerly scientific assistant in cereal and forage-crop insect investigations, Bureau of Entomology, United States Department of Agriculture, has died from wounds received when the British airplane in which he was serving as a flying observer was shot down. Lieutenant King was attached to the staff of the Wellington, Kans., field laboratory and was in charge of the Charleston, Mo., station prior to November 5, 1914, when he resigned to enter the British army.

EDUCATIONAL NOTES AND NEWS

MOUNT UNION COLLEGE, Alliance, Ohio, has received \$512,000 for endowment and equipment to increase its educational work. Successful completion of this fund was made possible by the gift of \$50,000 by the friends of the late Captain Milton J. Lichty, M.D., of Cleveland. The professorship of biology will be named in his memory.

THE *Journal* of the American Medical Association states that the national government has modified the statutes of the University of Cordoba in accord with the general demand on the part of professors, students and graduates, giving them a more democratic control. The Academia will retain only its scientific functions, while the direction of the different de-

partments of the university will be in the hands of a managing board for each. The members of these *consejos* are to be elected for a term of three years at a general assembly of all the professors.

BECAUSE of almost continuous absence of Dr. Richard P. Strong since the outbreak of the war, the department of tropical medicine of the Harvard Medical School, has been placed in charge of Dr. Andrew W. Sellards, whose title as associate is now made that of assistant professor.

PROFESSOR C. A. SISAM, of the University of Illinois, has accepted the headship of the department of mathematics in Colorado College. He has been connected with the University of Illinois since 1906.

DR. GEORGE R. BANCROFT has resigned the professorship of chemistry and physics in Transylvania College, Lexington, Ky., to accept a position at the University of Kentucky as assistant professor of organic and physical chemistry.

DR. CHARLES T. BRUES has been promoted to be assistant professor of economic entomology in Harvard University.

DISCUSSION AND CORRESPONDENCE

A MUSICAL, CRICKET-LIKE CHIRPING OF A GRASSHOPPER

IN August, 1917, I made frequent trips to a certain swamp near Spring Hill, Vinson Station, Va., to study the stridulating habits of a colony of locusts, *Neoconocephalus Exiliscanorus* (Davis), which have been located here for several years. The usual notes of the cone-headed grasshoppers (*Neoconocephalus*) are quite devoid of any musical tone such as is characteristic of the chirpings and trillings of the crickets. In truth, the sounds produced by these insects are usually harsh, lisping or rasping noises which may be intermittent or prolonged, depending upon the species. The stridulations of the cone-headed grasshopper (*N. Exiliscanorus*) are of the intermittent type, and are brief, insistent phrases—zeet—zeet—zeet—zeet—zeet, delivered very regularly

for a certain period, followed by a brief pause before the performance is repeated. The notes of the members of the particular colony located near Spring Hill appeared to be rather louder than the notes of some individuals of this species which I have heard elsewhere.

On the evening of August 21, I again visited this colony, the individuals of which were just beginning their usual nocturnal stridulations. While listening to their rather harsh, unmusical phrases, a loud, musical chirping started up, low down in the herbage and underbrush nearby. It was similar to the chirping notes of a cricket, and possessed the true tonal quality characteristic of the notes of such crickets as are found in the genera, *Gryllus*, *Ecanthus*, or *Orocharis*. I was actually somewhat startled by the loud, unfamiliar chirping, for I could not think of any species of cricket in this locality which I had not determined. After a careful search with a pocket flashlight, I located the musician, which, much to my surprise, proved to be the cone-headed grasshopper (*N. Exiliscanorus*). With the exception of the acquired cricket-like, musical pitch or tonal quality, the notes were delivered in a manner typically characteristic of this cone-headed grasshopper. I captured the insect and compared its tegmina with the tegmina of individuals stridulating in the normal manner, but could determine no particular differences in the stridulating field or the stridulating veins. A microscopic examination of the character of the teeth of the stridulating vein revealed nothing which could be considered responsible for the unusual character of stridulation.

It has always been a mystery to me why the crickets as a class produce stridulations characterized by the musical qualities of pitch and timbre, while the majority of the musical Orthoptera produced only lisping or harsh, strident, unmusical sounds such as are characteristic of the species of *Conocephalus*, *Orchelimum*, *Neoconocephalus*, *Atlanticus*, *Amblycorypha*, *Pterophylla*, etc. The question of the origin and evolution of the musical impulse as a dominant feature in the development of the Orthoptera must ever excite the

mind to wonder. In this class of insects, sound has become an almost constant and irrepressible feature of their lives. How did the tonal quality become acquired and why is it so constantly associated with the crickets? It is evident that this more musical quality may arise suddenly in the individuals of a species which normally produce only "noise," so to speak, as in the case of the cone-headed grasshopper mentioned. If such a change were associated with the germinal constitution so that it became a transmissible feature and not a merely accidental or temporary individual feature, it would suggest how a musical, cricket-like chirp could arise from a mere rasping note or "noise," and persist as a racial feature. If this were true, the sudden acquirement of the character would be in the nature of a mutation or discontinuous variation, and it is possible that evolutionary steps of this sort have actually occurred in the specialized development of stridulatory powers among the Orthoptera.

H. A. ALLARD

WASHINGTON, D. C.

SCIENTIFIC BOOKS

Field Book of Insects. With Special Reference to those of Northeastern United States. Aiming to Answer Common Questions. By FRANK E. LUTZ, PhD. G. P. Putnam's Sons. ix + 509 pp. 101 plates.

The text-books dealing with American insects are all excellent but are comprehensive and prepared for the use of students and advanced workers. None of them, however, cover just the field of the present volume. In European countries, where there are many more persons interested in the collection and study of insects than in America, a large number of small well-illustrated volumes are available, where the collector can identify his specimens as well as obtain information regarding their habits. These volumes are of such size that they can be slipped in the pocket and taken into the field for ready reference. There are "Field Books" dealing with American plants and birds, but this is the first one dealing with insects.

Although the "Field Book of Insects" covers a large field, it is convenient in size, 7 x 4½ x 1 inches, weighs about sixteen ounces, and while printed from small type, the printing is well spaced, clear and easily read. There are 101 plates, of which twenty-four are colored. The plates contain 800 figures, which are well drawn and will be of great aid in the identification of specimens. While the majority of the figures are of adult insects, there are many of nymphs, larvæ and pupæ, illustrating the common and peculiar types.

In the choice of the species to be described and figured, the author has evidently made use of his museum experience. The selection is excellent and includes all the common and anomalous species most likely to be met with by the amateur and general collector in the region covered, the northeastern United States. The discussions are interesting and concise. The introduction includes a general discussion on the number of kinds of insects, the scientific names of animals, growth and metamorphosis, anatomy, collecting and breeding of insects, identification and the control of injurious species.

There follows a brief account of the near relatives of insects, but confined in great part to spiders and their webs. The insects are divided into about twenty orders, of which the greater part of the text and a considerable number of the plates are devoted to the Hemiptera, Lepidoptera, Coleoptera, Diptera and Hymenoptera. While it is evidently intended that the figures should be used mainly for the identification of specimens, in the orders named there are analytical tables for the identification of families and genera and, in certain cases, species. The discussion of the Hymenoptera, the last order treated, is followed by a consideration of the abnormal growths or galls produced upon plants by insects. About the only way in which such structures can be identified is by the use of figures and the last seven plates contain figures of the common galls made by mites, Homoptera, Lepidoptera, Diptera and Hymenoptera. In interesting young people, those who tramp and camp, the student of

nature, and the farmer who observes the things about him, this book will prove of great value.

ALEX. D. MACGILLIVRAY

NOTES ON METEOROLOGY AND CLIMATOLOGY

RAINFALL OF THE UNITED STATES

MUCH progress has been made in accurate mapping of the rainfall of the United States, and in careful discussion of our now extensive records. In 1917, the Weather Bureau finished the construction of many maps designed to bring out the rainfall features of most importance in agriculture. Possibly by the end of this summer these will be published as a section of the Atlas of American Agriculture. In fact, the map of average annual precipitation has already appeared.¹

The most important of the unpublished maps are those of the monthly and seasonal rainfalls, and of the frequencies of rains of different intensities. Since the records of several thousand stations have been used, and since the isohyetal lines have been drawn with a careful consideration of topography, these maps show in much greater detail and accuracy than ever before the distribution of the rainfall of the United States.

The distribution has been ably discussed by Professor R. DeC. Ward.² The rainfall of the United States east of the Rockies seems to be from moisture originally coming from the Gulf of Mexico and the Atlantic Ocean; and, judging from the distribution of rainfall, the Gulf of Mexico is of primary importance. From the heavily watered north Gulf coast, where the rainfall is 60 inches a year, the amount decreases inland, slowly to the north, but rapidly to the northwest and west. East of the Appalachians the moisture from the Atlantic keeps the country well supplied—the rainfall being generally 45–50 inches in the south, and 40–45 in the north. The effect of the Appalachians is to increase the rainfall on the borders but to decrease the rain in the interior of the mountain region. Thus there

¹ See the reproduction in the *Mo. Weather Rev.*, July, 1917, Vol. 45, Pl. 76.

² *Ibid.*, pp. 338–345.

are local maxima of over 50 inches on the slopes well exposed to moist winds; but minima of less than 40 inches in the valleys. The extremes are over 80 inches on the exposed southern face of the Appalachians where North Carolina, South Carolina and Georgia meet; and under 30 inches in the enclosed Champlain valley. Without the abundant moisture which sweeps northward unobstructed all the way from the Gulf of Mexico, the Great Lakes could hardly exist. Since they are present, they exert a local effect on the climate; and increase the rainfall by perhaps 5 inches, making the total thereabouts 35 inches. Contrasts between windward and leeward shore rainfalls are not marked, for the light precipitation which occurs frequently with the cool westerly winds, and the heavy rainfall which comes with the less frequent easterly winds nearly balance. Of the well-watered eastern half of the United States, Professor W. M. Davis says:

The world hardly contains so large an area as this so well adapted to civilized occupation.^s

West of the 95th meridian, the rainfall lines run north and south instead of east and west, as is the case to the east. At about the 100th meridian the rainfall becomes too small for ordinary methods of farming, being less than 20 inches in the north and under 25 inches in the south. From here west to the Rockies the rainfall decreases almost to ten inches; so the Great Plains region is one of grazing, dry farming, or local irrigation. In the outlying highlands and the mountain front, the rainfall again rises to 15 or 20 inches. In comparison with the heavily forested east this open country was easily—in some areas, too easily—settled; but the fluctuations of rainfall in this marginal region make man's hold too precarious to favor a dense population.

The Interior Plateau and Basin region, walled off by high mountains, is arid. The rainfall of the northern Rockies exceeds 40 inches in Idaho, but is under 30 inches else-

^s "Elementary Meteorology," Boston, 1894, p. 301.

where; the central Rockies locally enjoy more than 30 inches, but the high plateaus of the south receive but 15 to 25 inches. The lower mountains and plateaus and the valleys in the rain-shadow of the Cascades and Sierras are arid, with less than 10 inches of rainfall. This aridity becomes extreme in the south; there, with lesser cyclonic activity, and greater heat, the rainfall averages under 5 inches a year. Water for the irrigation of these driest regions is not altogether lacking, for, except in the south, they occur in the lee of the wettest mountains. Thus, the Cascades with rainfall 10-15 times as great as that in the Yakima valley, supply abundant water for this great orchard.

The cause of aridity in the rain-shadow of the Cascades and Sierra Navadas is apparent from a glance at the excessive rainfall on the western side of the coast ranges and these higher mountains. South to the 40th parallel the rainfall exceeds 80 inches, and on the west flank of the Olympics, even 120 inches. In California, the rainfall decreases rapidly southward, while on the mountains of southern California, the amounts are under 30 inches, and on the coast at San Diego even less than 10. The cause of the heavy rainfall is the rapid cooling of the moist air which is blowing almost continuously from the Pacific. This cooling is brought about (1) by the expansion of the air as it is forced to rise over the obstructing mountains; (2) by the similar cooling as this air rises in the numerous cyclones; and (3) by cooling to the cold ground in winter. Diminishing cyclonic activity and increasing warmth of the land cause a southward tapering of the rainfall. The trough between the coast ranges and the higher mountains on the east receive only half as much rainfall as the mountains on either side; thus in many parts of the valleys irrigation is necessary particularly in the San Joaquin valley and in southern California. Water is supplied abundantly by the slow-melting mountain snows. Unlike the eastern United States, then, the western United States has sharp contrasts of rainfall in short distances; and because the rainfall is excessive on the moun-

tains, where it is not needed for agriculture, it is deficient on the lowlands, where man has to irrigate. However, the aridity of parts of the West has some compensation in the extensive forests of tremendous trees on the soaking slopes of the Pacific.

SEASONAL DISTRIBUTION OF RAINFALL

In some respects, the distribution of rainfall throughout the year is more important than the amount. On this depends the rainfall usable for agriculture, and likewise the effects of rainfall on soil. Thus the 25 inches of rainfall in Nebraska are as useful for crops as 40 inches in Virginia. In fact, the extra 15 inches in Virginia may do more harm than good, on poorly kept farms at least, by washing and leaching the soil.

Rainfall comes (1) in general cyclonic rains, (2) in local convectional (thunder) showers, and (3) in topographically produced falls. The cyclonic rains are greatest with frequent strong cyclones in regions where there is abundant moisture. The thunder-showers are most numerous in mid-summer⁴ unless at this time the supply of moisture is not abundant. The topographically produced rains are heaviest when there is the greatest cooling of the moist winds. In the United States, general cyclonic rains on the Pacific coast and in the eastern third of the country are heaviest in the colder months. Thunderstorms are common in summer in the wetter parts of the country west of the Sierra-Nevada-Cascades. Topographically produced rains are important on the Pacific, Gulf and Atlantic coasts, and on the windward sides of mountains; they are essentially early winter rains.

Professor Ward has picked out 14 well-recognizable rainfall types in the United States; and he has made composite curves and discussed each.⁵ The rains east of the Rockies tend to be heaviest in summer, and those west, in winter. The type covering the greatest region is the continental "Missouri" type. It

has a summer rainy season with a maximum of over 4 inches in June and a minimum of 1 inch in January. This shades off into many types on all sides. The Ohio type may be considered as the Missouri type with 1 to 2 inches of cyclonic rain added through the cold half of the year. The New England type has still more of the cyclonic winter rainfall, with 3 to 4 inches of rain every month. Farther south the Atlantic has an intensification of the July and August rainfall with the very favorable moisture conditions for thunderstorms and with the occasional heavy rain of tropical cyclones. The Tennessee type includes so much rainfall from the strong cyclonic action in February and March that the principal maximum, 4½ inches comes at this time; and there still is the summer maximum.

The Gulf coast is always moist. There are three types of rainfall—different combinations of thunderstorm and cyclonic rains—all with maximum intensity in the warmer half of the year.

In the East Rocky Mountain Foothills type, the rainfall in spring starts off like the Missouri type, but the winter snows are insufficient to supply moisture for increasing thunderstorm rains beyond May. The winters are dry in spite of numerous cyclones, because the air can contain so little moisture at the low temperatures. West of the crest of the Rockies, the moisture from the Pacific is precipitated topographically most in winter. In the plateau region, summer convection, especially before the ground is thoroughly dried, brings another maximum early in summer. In the south, however, the winter precipitation is so light and so soon evaporated that the summer showers do not occur till July when moisture arrives in sufficient quantity from the Gulf of California and the Pacific. On the north Pacific coast where there is much cyclonic activity throughout the winter the maximum comes in December (over 7 inches) when the topographic rainfall tends to be heaviest. In the south, cyclonic activity is more important than the cooling of on-shore winds in producing rainfall, so the heaviest rains in the "Southern Pacific" type occur from January

⁴ See *Mo. Weather Rev.*, Vol. 43, 1915, pp. 322-340, 13 charts; and pp. 619-620.

⁵ *Geogr. Review*, Vol. 4, 1917, pp. 131-144.

to March. Correspondingly, without cyclones, the summers are practically rainless.

The diverse rainfall types of the United States as well as the essential features of the distribution of rainfall may be held in mind if the essential features which produce rainfall are remembered.

CHARLES F. BROOKS

COLLEGE STATION, TEXAS

SPECIAL ARTICLES

A PARALLEL MUTATION IN *DROSOPHILA FUNEBRIS*

A MUTANT of *Drosophila funebris* Fabr. has recently appeared that is so strikingly similar to a well-known mutant of *D. melanogaster* Meig. (*ampelophila* Loew) that there can be little doubt that the same mutation has occurred independently in the two species. The new form, called notch, agrees with the notch *melanogaster* in at least eight different respects, as will appear below.

Origin.—A female *funebris* of a stock from Mitchell, S. D., was mated to a male of a stock from New York City. The descendants were mated in pairs for several generations, and no variations were observed except an occasional fly with one of the anterior scutellar bristles missing. Such flies were found also in the uncrossed New York stock. In the line under consideration selection was carried on, in an attempt to increase the percentage of such flies, but no marked result was obtained. In F_2 one pair (5201) produced 35 normal females, 34 notch females, and 36 normal males. The sex ratio here is significant, since an excess of males is more frequent than an excess of females in this species. The pair from which the parents of 5201 came produced 19 females and 31 males, which is not an unusual excess when complete counts are not obtained. In *D. funebris* the males usually emerge in a little less time than the females. This relation is just the reverse of that found in *D. melanogaster*. Evidently the female parent of 5201 was genetically notch. She was not observed to be abnormal, and had been destroyed when her offspring began to emerge. It seems probable that she did not have

notched wings, but she may well have had the characteristic veins and acrostichal hairs, since these would more easily have been overlooked.

Description.—Notch *melanogaster* is characterized by having the wings somewhat nicked, more especially at the apical posterior corner. But this character is somewhat variable, being often unlike in the two wings of the same female, and sometimes even entirely absent.¹

In addition the eyes are often smaller than those of the wild-type flies and somewhat roughened.²

Furthermore the veins of notch are somewhat thickened, more especially the apical portions of the second and fifth longitudinal veins. This character is the most invariable and convenient index of the presence of the notch gene. The anterior scutellar bristles of notch are often doubled. The acrostichal hairs are more numerous than those of the wild-type fly, and are irregularly arranged, instead of being in eight fairly definite rows.³ The notch gene thus produces an unusually large number of morphological peculiarities.

Notch *funebris* agrees in all of the above respects. The wings are nicked in the same way, but are often asymmetrical and sometimes normal; the eyes are often small and roughened; the wing veins are thickened even more than those of notch *melanogaster*, the second and fifth being affected most, and this character being again the most convenient and reliable for purposes of classification; the anterior scutellar bristles are often doubled, in spite of the fact that notch arose in a family selected for the absence of these bristles; the acrostichal hairs are irregularly ar-

¹ See Morgan, 1917, "The Theory of the Gene," *Amer. Nat.*, 51, for figure and a discussion of this variability.

² Bridges has shown that notch is probably an allelomorph of the roughened eye known as facet. Metz and Bridges, 1917, "Incompatibility of Mutant Races in *Drosophila*," *Proc. Nat. Acad. Sci.*, 3.

³ The peculiarity of the acrostichal hairs was not observed here until it was looked for after notch *funebris* was found to have unusual acrostichals.

ranged, but differ from those of notch *melanogaster* in being entirely wanting on each side in a narrow band just inside the dorso-central row.

The unusual features of notch in *melanogaster* are not limited to its morphological nature. Notch is one of the few dominant mutant genes, and in addition is sex-linked and has a recessive lethal effect. The result is that a notch female gives equal numbers of wild-type and notch daughters and of wild-type sons. Notch males never appear. This is the only known dominant sex-linked gene that is also lethal—except *funnebris* notch. We have seen that the original notch culture, 5201, gave the characteristics 1: 1: 1: 0 ratio; and this has been repeated by the notch females produced in that culture, both when mated to their brothers and when mated to unrelated wild-type males.⁴

The striking parallel between these two mutants makes it highly probable that they represent the same genetic change. This view is strengthened by the fact that notch is one of the most frequent mutations in *melanogaster* (known to have occurred seven times), and might therefore be expected to be one likely to occur in another species.

Summary.—Notch *melanogaster* and notch *funnebris* agree in the following respects:

1. Wings usually irregularly nicked at tip.
2. Certain veins thickened.
3. Eyes often small and roughened.
4. Acrostichal hairs not in definite rows.
5. Anterior scutellar bristles often doubled.
6. Character is dominant.
7. Gene has a recessive lethal effect.
8. Gene is sex-linked in *melanogaster*, almost certainly so in *funnebris*.
9. Mutation is one of the most frequent in *melanogaster*, and the first certain one in *funnebris*.

A. H. STURTEVANT

COLUMBIA UNIVERSITY,
May, 1918

⁴It is theoretically possible that *funnebris* notch is not sex-linked, but that the gene is dominant in females, lethal in males. This can be determined by finding gynandromorphs, or by finding other sex-linked genes and observing their linkage to notch.

THE KENTUCKY ACADEMY OF SCIENCE

THE Kentucky Academy of Science held its fifth annual meeting at the University of Kentucky on Saturday, May 4, 1918, with Mr. J. E. Barton, vice-president, in the chair. After a brief business session, at which several new members were elected, the following program was presented:

President's address, by J. E. Barton, acting president, "The regenerative forests of eastern Kentucky and their relation to the coal-mining industry." The extensive coal-measures of eastern Kentucky support a valuable forest growth, which is of great usefulness in the mining of coal. At the present time it takes about three acres of timber to mine one acre of coal. The ratio should be nearly one acre of timber to one acre of coal. This condition can be brought about by careful management, which is justified by the fact that the coal supply will last about one hundred years, at present rate of production. Timber can be raised in a thirty-year rotation, of sufficient size and character for mining purposes, by a proper selection of species, an area fully stocked and adequate protection against fire and live stock.

Differences in the ossification of the male and female skeleton: DR. J. W. PRYOR.

Scientific education: J. J. TIGERT. The rapid development of scientific agriculture. Education followed agriculture in scientific progress. Scientific procedure dependent upon quantitative measurement. Statistical methods and measurements in education. Standard tests. The measurement of intelligence. Charts and tables showing results of measurements in the Cynthiana schools in 1916-17 and the Lexington schools in 1917-18. Age-grade table, Cynthiana, shows 22 per cent. of pupils retarded. Comparison of promotions in Cynthiana and other American cities shows a larger percentage of promotion in Cynthiana than elsewhere. Ayres Spelling Test in Lexington and Cynthiana shows Lexington three points above the average of 84 American cities, and Cynthiana equal to the average of 84 American cities. Handwriting tests in Lexington and Cynthiana show both these cities below the average city in speed and quality of handwriting. Arithmetic tests in Cynthiana show Cynthiana below standard measured by the Woody Scale. A comparison of boys and girls in spelling and handwriting shows the girls to be superior to the boys.

The effect of manganese on the growth of wheat: J. S. MCHARGUE. After reviewing briefly some noteworthy results obtained by previous investi-

gators on the relation of manganese to agriculture, the author presented results obtained by growing wheat in manganese-free sand and in cultural solutions, with and without the addition of manganese.

Wheat plants grown to within a few weeks of maturity in cultural solutions containing manganese and others of the same age in which the manganese had been omitted, were on exhibition. Where manganese had been added to the cultural solutions the plants were apparently normal in every respect, whereas the plants grown in solutions containing no manganese showed a retarded growth in the blades, stalks and roots, as compared with the plants of the same age receiving manganese. There was evidence of lack of the proper development of chlorophyll in the plants receiving no manganese and the blades of these plants exhibited a drooping appearance in that they were not able to hold themselves erect, which was quite characteristic and not to be observed in any of the plants receiving manganese.

The author concludes from his experiments that manganese plays a more important rôle in the growth of wheat than has hitherto been suspected.

Formation of petroleum: C. J. NORWOOD. (By title.)

Cryoscopic work with an ordinary thermometer: C. C. KIPLINGER. It has been found possible to read small temperature intervals on a common thermometer, within an accuracy of 1/100 degree, by measurements of the parallax on an auxiliary scale equipped with a sliding peep-sight.

Several heretofore troublesome sources of error in the boiling point method of determining molecular weights have been eliminated by using but one point as reference on a thermometer scale, having established this point by the use of a known substance with a high degree of purity. This procedure eliminates the need of a calibrated thermometer.

The use of the parallax method is suggested in the estimation of fractional parts of a scale division on other instruments than the thermometer.

Generalization on the mean-value theorem: H. H. DOWNING.

Magnolia fraseri: does it occur in Kentucky? FRANK T. MCFARLAND.

List of fungi from Kentucky: FRANK T. MCFARLAND.

An equation balance: E. L. REES.

A method of constructing the graph of an equation in which the variables may be separated: E. L. REES.

Protein metabolism in the growing chick: G. D. BUCKNER and others. (By title.)

Review and observations on the mosaic disease of tobacco: G. C. ROUTH. The author reviews the work of other investigators and reports observations of his own upon the disease in experimental plots of different varieties of tobacco. He favors the view that the best way to combat the disease will be to develop a resistant strain of tobacco.

Dr. J. A. Detlefsen, of the department of genetics of the University of Illinois, addressed the academy on "Laws governing the transmission of characters from parent to offspring."

The speaker gave a brief review of the search by investigators for the cause or causes of evolution. He then explained the law for the transmission of mono-hybrids, di-hybrids and tri-hybrids. He presented these laws and illustrated them so well that there was left no doubt in the minds of workers in other fields that great progress has been made in genetics in recent years.

He threw upon the screen the tables giving the result of his own breeding experiments to show how nearly actual counts agree with the mathematical expectation, in the laws of transmission. It is remarkable how nearly actual counts of animals bred agree with the expectation of what, by Mendel's law, they should be.

Among other items of business, a resolution was passed offering the services of the academy to the U. S. government for any war work in which this organization might be of assistance.

Officers were elected as follows:

J. E. Barton, Frankfort, President; P. P. Boyd, Lexington, Vice-president; A. M. Peter, Lexington, Secretary; J. S. McHargue, Lexington, Treasurer.

ALFRED M. PETER,
Secretary

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THE ZONE POSTAL RATES

Owing to its national circulation, SCIENCE is heavily taxed by the new law imposing zone rates on the advertising parts of second-class matter. This law appears to be unfortunate from the point of view of maintaining national interests and national unity. It is desirable that those readers of SCIENCE who share this point of view should write to congressmen and senators from their states urging the repeal of the zone law. The question is clearly stated in the following letter from the Honorable Charles E. Hughes addressed under date of June 17, 1918, to the Publishers' Advisory Board:

In answer to your letter, I beg to say:

I prefer not to accept a retainer to appear before legislative committees upon matters of general policy, as in such matters, if I have anything to say, I desire to speak only as a citizen.

I have no hesitation in saying that I regard the zone system of postal rates for newspapers and periodicals, coming under the definition of second-class mail matter, as ill advised. The Commission on Second-Class Mail Matter (appointed in 1911), of which I was a member, considered this question and reported unanimously against the zone system. We said in that report:

"The policy of the zone rates was pursued in the earlier history of our post office and has been given up in favor of a uniform rate in view of the larger interest of the Nation as a whole. It would seem to the Commission to be entirely impracticable to attempt to establish a system of zone rates for second-class matter. * * *

"Progress in the post office, with respect, both to economy in administration and to public convenience, leads away from a variety of differential charges to uniform rates and broad classifications."

In my judgment the zone system for second-class mail matter is unjust to the publisher and unjust to the public. It not only imposes upon the publisher the additional rates upon a sectional basis, but it makes necessary the added expense for the necessary zone classifications at a time when every economy in production and distribution is most important. It introduces a complicated postal system to the inconvenience of the publisher and public when there should be a constant effort toward greater simplicity. There is no more reason for a zone system of rates for newspapers and magazines than for letters.

Newspapers and magazines are admitted to the second-class postal rates on the well established policy of encouraging the dissemination of intelligence, but a zone system is a barrier to this dissemination. If it is important that newspapers and magazines should be circulated, it is equally important that there should not be sectional divisions to impede their general circulation through the entire country.

We are proud at this moment of our united purpose, but if we are to continue as a people to cherish united purposes and to maintain our essential unity as a nation, we must foster the influences that promote unity. The greatest of these influences, perhaps, is the spread of intelligence diffused by newspapers and periodical literature. Abuses in connection with second-class mail matter will not be cured by a zone system of rates. That will hurt the good no less than the bad, and perhaps some of the best sort of periodical literature will be hit the hardest.

We do not wish to promote sectionalism, and "one country" means that in our correspondence and in the diffusion of necessary intelligence we should have a uniform postal rate for the entire country. The widest and freest interchange is the soundest public policy.

I hope that Congress will repeal the provision for the zone system which is decidedly a looking-backward and walking-backward measure.

Very sincerely yours,

(Signed) CHARLES E. HUGHES